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**General Aviation
Manufacturers Association**

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March 27, 2000

U.S. Department of Transportation Dockets
Docket No. FAA-1999-6411-33
Room Plaza 401
400 Seventh Street, SW
Washington, DC 20590

SUBJECT: Comments to FAA NPRM 99-18, Transport Aircraft Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements

Dear Ladies and Gentlemen:

The General Aviation Manufacturers Association (GAMA) represents over 50 U.S. manufacturers of fixed wing aircraft, engines, avionics and components. GAMA has reviewed the subject Notice of Proposed Rulemaking No 99-18 that would require design approval holders of certain turbine-powered transport category airplanes to submit substantiation to the FAA that the design of the fuel tank system of previously certificated airplanes precludes the existence of ignition sources within the airplane fuel tanks, and proposes three amendments to the airworthiness standards for transport category airplanes.

GAMA member companies produce several different models of transport category aircraft which are primarily classified as business jets. Although the SFAR, as proposed, is not applicable to most of these airplanes (passenger capacity of 30 or more, or a payload capacity of 7500 pounds or more) the proposed amendments to Part 25 airworthiness standards will significantly impact the design of all future business jets. In addition, the NPRM specifically requests comments on extending the rule to smaller airplanes. However, the proposed rulemaking and all related discussion (design, operations, maintenance, economic evaluation, etc) focuses almost exclusively on large aircraft operated by air carriers.

GAMA appreciates the opportunity to provide comments on behalf of our member companies. Some of these comments refer to portions of the rule that do not currently apply to most business jet aircraft. These statements are made on the merits, justification, cost/benefit, etc. of the SFAR based on perceived concerns in the NPRM if it were to be extended to smaller aircraft. We offer the following specific comments.



A. GAMA Endorsement of Aviation Industry Response

A collective *Aviation Industry Response* to FAA NPRM 99-18 was developed through the coordination of several domestic and international industry associations of both manufacturers and operators. Although GAMA is not a direct signatory of these comments, several member manufacturers are also members of the sponsoring organizations and participated, to some extent, in the development of these comments. Through this comment to the docket, GAMA expresses an explicit endorsement of the comments made in the *Aviation Industry Response* to FAA NPRM 99-18. However, those comments focus specifically on the large transport category aircraft and the associated operators for which the proposed SFAR applies.

Therefore, these additional comments are independently submitted as a supplement to the industry response. These comments are necessary because of significant technical, operational, economical, and regulatory (FAR 91 vs 135 vs 121) differences between large commercial transport aircraft and smaller business jets.

B. Extension of SFAR Requirements to Smaller Aircraft

The NPRM specifically requests comments as to the feasibility of extending the SFAR design review, inspection and maintenance requirements to aircraft smaller than 30 passenger capacity or 7,500 pounds payload capacity.

In order to achieve the benefits of this rulemaking for large transport airplanes as quickly as possible, the FAA has decided to proceed with this rulemaking with the applicability of the SFAR limited to airplanes with a maximum certificated passenger capacity of at least 30 or at least 7,500 pounds payload. Compliance is not proposed for smaller airplanes because it is not clear at this time that the possible benefits for those airplanes would be commensurate with the costs involved. However, the FAA intends to undertake a full regulatory evaluation of applying these

requirements to small transport category and commuter category airplanes to determine the merits of subsequently extending the rule to airplanes with a passenger capacity of fewer than 30 and less than 7,500 pounds payload. Therefore, the FAA specifically requests comments as to the feasibility of requiring holders of type certificates issued prior to January 1, 1958, or for airplanes having a passenger capacity of fewer than 30 and less than 7,500 pounds payload, to comply and the safety benefits likely to be realized.

However, the proposed rule is not currently drafted in such a way that it could be extended to apply to business jet aircraft and their associated operations. The following comments are made on the merits, justification, cost/benefit, etc. of the SFAR based on perceived concerns in the NPRM if it were to be extended to smaller aircraft.

The majority, and possibly all, of FAR 25 certificated aircraft within this smaller size range are business jets. While it would be technically feasible to extend the SFAR to these smaller aircraft, the cost involved would not be justified by the safety benefits and could result in resources being

diverted from higher priority safety issues. Reasons and justification not extending the applicability are as follows:

1. Service experience justifies not extending the SFAR applicability. Of all known fuel tank explosion events, gathered from the ARAC FTHWG report and the FAA request for comments regarding fuel tank flammability, only one involved a business jet. The Beechjet 400 incident was the least severe of all the explosion events in that it resulted in no fatalities or injury and apparently the least amount of aircraft damage. Furthermore, the cause of this event, static charge accumulation on non-conductive reticulated foam, involved a design feature not widely used on the business jet fleet.
2. Part of the reason for this excellent business jet record is that business jet usage is typically within a range of 3 to 10 times lower than large commercial transports, and this is unlikely to change in the future. This not only results in fewer events if it were assumed the underlying rate were similar, but it also greatly reduces exposure to component or system degradation due to vibration or wear.
3. Several design factors typical of business jets reduce their susceptibility to conditions which could cause fuel tank ignition. There is little or no known usage of tanks with significant sources of external heat input. The typical use of 28 V. D.C. electrical power instead of 120 V. 3 phase A.C. power reduces potential for arcing damage to ignition barriers such as wiring conduits and boost pump housings, and reduces potential as a failure source of external energy input to Fuel Quantity Indication System (FQIS) wiring. Many business jet models feature electric fuel boost pumps which only operate intermittently, or are always submerged in fuel, or both.
4. Cost/benefit factors of SFAR extension to business jets would include costs lower than typical large transport airplanes combined with benefits disproportionately much lower. The conservative cost/benefit analysis in Attachment 1 shows a cost/benefit ratio for ignition protection of a hypothetical new model business jet to be 8.64 for compliance with proposed FAR 25.981 ignition source prevention requirements and guidelines. The cost/benefit ratio for the existing fleet could be even more unfavorable due to higher costs associated with retrofit of any required design changes.

C. Cost/Benefits Analysis of SFAR

There are several oversimplifications identified in the cost benefit analysis of the SFAR presented in the NPRM. They are as follows:

1. The potential future benefit is primarily based on service history involving two fatal accidents. Since both of the accidents involved airplanes with elevated fuel tank flammability exposure, the potential future benefit is understated for airplanes with this design feature. Conversely, the future benefit may be overstated for airplanes with reduced flammability exposure. The cost/benefit ratio for these different types of airplanes should be analyzed separately, and the required actions to provide acceptable safety be specified separately.

2. The NPRM analyzes costs for making design assessments and preparing recommendations for inspections and service requirements as required by the SFAR. It does not include costs to develop and retrofit design changes required by the SFAR. Design changes may be necessary for some model aircraft, since reduction of ignitions of 75-90% through inspections and service requirements, as estimated in the benefits analysis, does not necessarily provide the stringent FAR 25.981 ignition source compliance required by the SFAR. Detailed cost estimates for development and retrofit of design changes are not presented here, since they would be application specific.
3. The NPRM includes labor and downtime costs for additional inspections, but excludes component replacement costs on the grounds that replacement of defective components is required by current regulations. Additional component replace costs could, however, be incurred when the inspection procedure, including possible removal and re-installation, involves undue damage risk, or when additional scheduled replacement or overhaul are conservatively specified because of limitations on inspection techniques in ensuring future continued airworthiness to the high level of certainty required for compliance with the new rule. Additional costs for retrofit of design changes are also not included.
4. The NPRM cost analysis does not include costs of previous and ongoing AD activity to preclude ignition, however, the benefit analysis does not recognize that these activities would be expected to reduce the rate of future ignitions. The cost and benefit analyses should be consistent with each other.

D. Cost Benefit Analysis of FAR 25 Changes

The NPRM states that the discounted costs would be minimal for new type certificated airplanes because these designs costs would be incurred in the future by airplane models yet to be designed. This is considered to an oversimplification for reasons stated below.

1. Even in the absence of significant design changes required for compliance with the rule change, the NPRM background discussion clearly indicates that greater effort will be necessary for showing compliance and developing service information. For each new model this is estimated, at a minimum, to be approximately equal to the costs identified in the NPRM for SFAR design assessment and service instruction compliance. It should be reasonable to estimate the number of new TC's, amended TC's, and STC's in the next ten years by extrapolation of the trend for the last ten years. Furthermore, application of the proposed rules to amended TC's does not fall in the category of "airplane models yet to be designed" as stated in the NPRM.
2. Some airplane models may require design changes for compliance which could result in non-recurring, recurring and operation costs. Potential difficulties in compliance with the ignition source requirements, depending on application and interpretation of the requirements, and potential difficulties with compliance with the flammability requirements for certain types of tanks (those which are not heated, but cool more slowly than wing tanks), could force the use

of measures such as fuel tank inerting or explosion protection, which were identified in the ARAC FTHWG report as being extremely costly and not justified based on cost/benefit ratio. Technical issues associated with these possibly required design changes are presented below in the FAR 25 rule change comments.

3. A conservative cost benefit analysis for a new model medium size business jet requiring modest design changes for ignition source compliance, but requiring additional measures (reticulated foam is analyzed) for flammability compliance of fuselage tanks, is contained in Attachment 1. The analysis shows that the combined costs for ignition source and flammability compliance exceed conservatively projected 100% benefits by a factor of 232, while the costs for ignition source prevention alone exceed conservatively projected 100% benefits by a factor of 8.34.
4. In addition to the absence of cost analysis of the proposed FAR 25 rule change, there is also no benefit analysis independent of the SFAR.

Based on the above, it is recommended that the proposed FAR 25 changes be justified by cost benefit analysis independent of the SFAR, or be withdrawn. It is further recommended that the cost benefit analysis distinguish between different broad classes of airplanes to which the proposed rule changes would apply.

E. Comments to Proposed FAR 25.981 Combined Ignition Source and Flammability Limitation Requirements

There is no disagreement with the basic intent of preventing explosions in fuel tanks, however, the proposed rules as stated, and as interpreted in the discussion section of the NPRM, may be internally inconsistent and inconsistent with other FAR 25 safety requirements.

The rule addresses an ignition source as a catastrophic condition with associated failure probability requirements, which is inconsistent with FAR 25.901(c) and FAR 25.1309, since an ignition source does not cause a hazardous or catastrophic condition unless ignition also occurs. For this to occur the ignition source must not be submerged in fuel, the fuel vapor and air mixture exposed to the ignition source must be flammable, and the ignition source must be strong enough to cause ignition when considering factors such as flammability, spark gap and quenching effects, altitude, etc. Assumptions that ignition sources always cause ignition lead to the conclusion that these other factors don't matter. Such conclusions penalize airplanes in which these other factors are minimized and possibly have contributed to designs which have experienced catastrophic ignitions. Service history of turbine engine transport category airplanes does not justify that fuel tank ignition sources, which may not even cause ignitions, must be controlled this much more stringently than other failure conditions or operational conditions which can cause catastrophic accidents.

This separate requirement for ignition source prevention and flammability minimization leads to one of two conclusions:

- It may not be possible to comply with the ignition source requirements, therefore, it is necessary to include flammability limitation in order to provide an acceptable level of safety. If this is the case, it is not appropriate to publish ignition source regulations for which compliance may not be possible.
- It is possible to comply with ignition source requirements, which provide an acceptable level of safety even if the extremely conservative assumption is made that ignition sources result in a 100% occurrence of actual ignition events. If this is the case, the flammability limitation requirements are not necessary.

It is recommended that the proposed rule be revised to specify that the failures addressed shall not result in a fuel tank ullage ignition occurrence instead of not resulting in a fuel tank ignition source.

F. Comments to Proposed FAR 25.981 Ignition Source Requirements

The requirement discussed in the NPRM discussions section to assume a probability of one for environmental factors within the certification basis (HIRF is mentioned, but presumably others such as lightning are also intended), when this is known to not be the case, may be appropriate in combination with single failures or latent failures, but is not appropriate or justified in combination with multiple failures requiring an extremely improbable probability of occurrence.

There are significant difficulties with the requirement that an ignition source not be caused by a single failure in combination with a latent failure not shown to be extremely remote. Exposure to a latent failure is a combination of probability of occurrence and duration. The proposed rule treats short duration failures the same as long duration failures. This is inconsistent with current application of 25.1309, where both the probability and duration of latent failures are considered in conjunction with the probability of additional failures. The statement in the discussion section that proposed latent failure requirement is currently required under 25.901(c) is not supported by reading of 25.901(c), and is not known to have been subject to the appropriate rulemaking procedures.

The rule also requires specific and detailed continued airworthiness instructions, whose main purpose is to detect and correct latent failures (otherwise they wouldn't be latent). It is questionable whether inspection practices with the required inspection intervals and probability of detection are technically practical and economically feasible.

It may not be possible to show strict compliance, either qualitatively or quantitatively, with some of the conditions required to be assessed. One example, but not the only example, is fuel static electrification. There are well known design practices to minimize the hazards of static electrification. Service history generally, but not completely, demonstrates their effectiveness, however, this may not be sufficient to show strict compliance with the preclusion or probability

requirements of the rule. Review of available guidance and literature on this subject tends to indicate the absence of a bottom line, and reveals no known methodology which could be used to show strict compliance. Other areas with similar difficulty in showing strict compliance, include damage, wear, negligence in maintenance or overhaul, etc.

G. Comments to Proposed FAR 25.981 Fuel Tank Flammability Requirements

The discussion section of the NPRM states that practical means are required to minimize fuel tank flammability to preclude designs which increase the likelihood of flammability compared to readily available alternatives. It also states that the intent of the rule is to require that fuel tanks are not heated, and cool at a rate equivalent to the wing tank in the airplane being evaluated. It further states that this may require providing or increasing ventilation means for some tanks.

The above statements are not consistent for a variety of widely used tanks which cool more slowly than wing tanks, but for which practical means such as increased ventilation cannot provide cooling equivalent to wing tanks. Such tanks may include cargo bay tanks in large transport airplanes, and tanks in many models of business jets, with a variety of fuel management considerations, located in a variety of locations such as fuselage tail cones, wing center sections, and various fairing compartments.

The ARAC FTHWG report analyzes the flammability of several typical large transport center tanks, but does not consider the complete range of tanks in this category probably due to understandable schedule constraints and priorities. It may not be practical to cool all of these tanks at a rate approaching that of the wing tanks for the following reasons:

- Many of these tanks are main feed tanks or are otherwise subject to greater operation exposure with significant fuel quantities, which is the critical cooling condition for a non-heated tank.
- Many of the tanks are of double wall construction, for fuel leakage safety reasons, with an insulating air space and/or insulating non-metallic walls, which slow the rate of cooling and are not conducive to cooling by increased airflow to the tank exterior.
- Many of the tanks are located and shaped such that it is difficult to provide large quantities of airflow.

There are several possible methods to overcome these difficulties and to comply with the proposed rule. One would be an airplane design which did not feature these types of tanks, however, design changes which affect the basic configuration of the airplane are not considered to be practical, especially for derivative airplanes to which the proposed rule may apply. Other methods would include design changes such as on-board fuel tank inerting or the installation of reticulated foam. Such means are not considered practical. If they were, it would be logical to require them on all fuel tanks. Additionally, use of ground based inerting is not practical for business jets, due to insurmountable infrastructure problems associated with the large number and variety of worldwide airport locations affected.

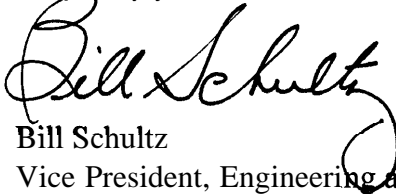
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As previously discussed, Attachment 1 contains a cost benefit analysis for installation of reticulated foam in affected tanks of a hypothetical new model medium size business jet for which the fuselage tanks would require protection. It is not possible to predict to what extent this hypothetical airplane may be representative of future new models of business jets. As can be seen, the ratio of costs to benefits is 232.

Another inconsistency is that requiring the flammability exposure of tanks to be no higher than the exposure of unheated wing tanks unnecessarily penalizes airplanes which have a low wing tank flammability exposure due to tank size or construction, and for which a somewhat higher exposure for other tanks would still not be excessive. For example, an airplane with 7% wing tank exposure would be allowed the same exposure for other tanks, while an airplane with 3% exposure for wing tanks could require expensive and impractical means to limit the exposure of other tanks to this value. It is recommended that the rule interpretation state that other tanks have a flammability exposure equal to that of the unheated wing tanks, or an exposure of 7% of operational time, whichever is higher.

GAMA appreciates the opportunity to comment on this rulemaking proposal. Please feel free to contact me if there are any questions.

Very truly yours,

A handwritten signature in black ink, appearing to read "Bill Schultz". The signature is fluid and cursive, with a large loop at the end.

Bill Schultz
Vice President, Engineering and Maintenance

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March 27, 2000
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Attachment 1

Cost Benefit Analysis For Fuel Tank Ignition Prevention And Flammability Limitation

Hypothetical Medium Size Business Jet

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Basic Aircraft and Fleet Data

Production Rate	40	Aircraft/Year
New Cost	\$12,000,000	
Flight Cost	\$2,000	\$/Flight Hour
Operational Period Analyzed	10	Years
Flight Usage	600	Flight Hours/Year
Average Flight	1.5	Hours
10 Year Fleet Usage	2,020	Aircraft-Years
	1,212,000	Aircraft Hours
	808,000	Flights
Average Passenger Load	4	Passengers
Passenger Load Range	0-8	Passengers
Crew	2	
Total Fuel Volume	1650	Gallons
Fuel Volume Requiring Flammability Reduction/Protection	750	Gallons
Method of Fuel Tank Flammability Reduction/Protection	Reticulated Foam	
Reduction In Full Tank Usable Fuel (4% of Protected tank volume).	203	Pounds
Reduction In Constant Fuel, Constant Takeoff Weight Payload (4% of protected tank volume).	203	Pounds

Ignition Source Prevention Cost

Item	Quantity	Units	Cost/ Unit	Non- Recurring	Manufacturing Recurring \$/Aircraft	Operational \$/Aircraft/ Year	10 Year Fleet Cost
<u>Design, development, certification</u>							
Engineering analysis and documentation	500	mh	100	50,000			50,000
Engineering design changes. ¹	250	mh	100	25,000			25,000
Manufacturing engineering	250	mh	60	15,000			15,000
<u>Manufacturing</u>							
Manufacturing cost of design changes. ¹	1	lot	1,000		1,000		400,000
<u>Operation</u>							
Increased inspection labor.	10	mh/yr	60			600	1,212,000
Increased inspection downtime	.2	days/yr	.07 ²			414	836,778
Precautionary component replacement labor.	5	mh/yr	60			300	606,000
Precautionary component replacement material.	300	\$/year	300			300	606,000
Total							3,750,778

Notes: 1. Nominal cost of minor design changes, such as relocation of fuel quantity signal conditioner adjacent to tank, and addition of wire shielding. More extensive design changes could cost more.
2. 7% yearly percentage rate applied to 90% of new aircraft value.

Fuel Tank Flammability Fluid Protection Cost (Reticulated Foam in Affected Tanks)

Item	Quantity	Units	cost/ Unit	Non- Recurring	Manufacturing Recurring \$/Aircraft	Operational \$/Aircraft/ Year	10 Year Fleet Cost
<u>Design, development, certification</u>							
Engineering design, analysis and documentation	2,000	mh	100	200,000			200,000
Program Delay Cost	3	days	.07 ¹	172,603			172,603
Shop Cost	600	mh	40	24,000			24,000
Manufacturing engineering	2,000	mh	60	120,000			120,000
Tooling	1	lot		120,000			120,000
Handbooks	1,000	mh	60	60,000			60,000
<u>Manufacturing</u>							
Labor (installation, material handling, flushing).	96	mh	40		3,840		842,184
Foam, material and fabrication.	750	gal.	2.81		2,105		1,536,000
Delivery delay	1	day	.07 ²		2,301		920,548
<u>Operational</u>							
Increased fuel burn ³	1.21	gal/hr	2.00			1,162	2,933,040
Weight/range limited operations ⁴	80	flights/yr	500			4,000	80,800,000
Increased Maintenance Labor	60 ⁵	mh/yr	60			3,600	7,272,000
Increased Maintenance Downtime	.4	days/yr	.07 ⁶			828	1,673,556
Foam Replacement ⁷	37.5	gal/yr	7.02			263	531,629
Total							97,086,000

- Notes:
1. 7% yearly percentage rate applied to \$300,000,000 program cost.
 2. 7% yearly percentage rate applied to new aircraft cost.
 3. Based on increased weight of 4% of fuel weight protected, and increased fuel burn of .04 lb/hr per 1 lb of increased weight.
 4. Based on 20% of operations being takeoff weight or fuel volume limited. The weight and fuel volume reduction of foam would result in reduced payload (foam weight is approximately equal to one passenger and baggage) or an extra stop to refuel. Cost is conservatively based on reduced productivity involving a payload reduction of one passenger, at a higher than average passenger load. Cost of an extra fuel stop could be from two to ten times higher depending on amount of extra flight time, amount of extra elapsed time, and value placed on increased elapsed time for passengers.
 5. Additional labor and downtime associated with removing, handling storing, and replacing foam for tank access for scheduled and unscheduled inspections and maintenance.
 6. 7% yearly percentage rate applied to 90% of new aircraft cost.
 7. Prorated material cost, including spares markup, of foam replacement due to age or deterioration at a twenty year interval during a scheduled maintenance activity which would require removal and reinstallation of foam anyway.

Benefit Analysis

Probability of catastrophic fuel tank explosion:

Condition	Probability Estimate	Basis for Estimate
Current and historical rules and practices.	1E-08 events/ flight hour.	Conservative lower estimate based of business jet service history of no catastrophic events to date.
Proposed rules.	0 events/ flight hour.	Conservative assumption of 100% effective.
Improvement	1E-08 events/ flight hour.	Difference.

Benefit:

Benefit = (Probability Improvement) x (Fleet Flight Hours) X (value of death prevention + value of aircraft + cost of investigation)

Benefit = (1E-08) x (1,212,000) x ((6 X \$2.7M) + (.80 x \$12M) + \$10M)

= \$ 433,896

Cost Benefit Ratio

For both ignition source prevention and tank flammability protection:

Costs/benefits = (3,751,000 + 97,086,000)/434,000 = 232

For ignition source prevention only (assuming 100% benefit still available):

Costs/benefits = 3,751,000 /434,000 = 8.64

Note that the cost benefit ratios would not change significantly if the analysis were extended beyond the 10 year operational period to the entire fleet operating life, for the following reasons:

- The majority of the costs are operationally and would continue to accumulate would operational life.
- The estimated tank explosion probability, based on service history, is an overall average which does not include variation with aircraft or fleet age.